# REMARKS

## STATUS OF THE CLAIMS

Claims 1-3 and 5-19 are pending in this application. Claims 1, 2, 5-7, 9-10, 12-15, and 19 have been amended. Claims 4, 18, and 20-42 have been canceled without prejudice. New claims 43-45 have been added. Following entry of the present amendment, claims 1-3, 5-17, 19, and 43-45 will be pending.

## SUPPORT FOR AMENDMENTS TO THE CLAIMS

Support for the claim amendments can be found throughout the specification and claims as filed. Therefore, no new matter is added by way of these amendments.

Claims 1, 2, 5-7, 10, 12-15, and 19 have been amended for clarity and consistency of claim language.

Claim 1 has been amended to provide that single wall carbon nanotubes are formed. Support for amended claim 1 can be found at least at original claim 18 and paragraph [0057] of the specification.

Claims 43-45 have been added and recite a bimetallic or trimetallic metalorganic layer thickness of less than 5 microns, 1 micron, and 2 micron, respectively. Support for new claims 43 and 44 can be found at least at paragraph [0057] of the specification. Support for new claim 45 can be found at least at paragraph [0061] of the specification.

## REJECTIONS UNDER 35 U.S.C. § 103

Claims 1, 3, 5-15, and 17-19

Claims 1, 3, 5-15, and 17-19 were rejected under 35 U.S.C. § l03(a) as allegedly being unpatentable over U.S. Pat. No. 6,232,706 to Dai et al. ("Dai") in view of U.S. Pat. App. Pub. No. 2002/0036452 to Muroyama et al. ("Muroyama"), and U.S. Pat. No. 6,692,717 to Smalley et al. ("Smalley"), and further in view of U.S. Pat. No. 5,872,422 to Xu et al. ("Xu"). According to the Office Action, "[i]t would have been obvious to one of ordinary skill in the art at the time of

the invention to modify Dai et al. and Muroyama et al. to include using bimetallic or trimetallic catalysts as taught by Smalley et al. in order to attain more control over the growth of single walled nanotubes … [and] to adjust the thickness of the metalorganic layer of Muroyama to within the claimed range as suggested by Xu …" (Office Action, p. 4).

Applicants respectfully disagree. In order to establish a *prima facie* case of obviousness, the cited reference (or references when combined) must teach or suggest each and every claim limitation. As described in detail below, the combination of Dai, Muroyama, Smalley, and Xu does not disclose each and every element of the claims, and, even if it did, the rejections are rebutted by applicant's showing of teaching away in the art.

**The Cited References Do Not Teach or Suggest Every Element of the Presently-Amended Claims**

Dai is directed to a method of making carbon nanotube bundles using an iron oxide catalyst disposed on a substrate, wherein the iron oxide catalyst is oxidized after deposition. As conceded by the examiner, Dai does not disclose using an organometallic Fe layer or that the catalyst may be bimetallic or trimetallic as recited in claim 1. (Office Action, p. 3). Dai also does not disclose a method for synthesizing single wall carbon nanotubes. For instance, Dai provides that "[t]he carbon nanotubes are generally multi-walled." (Dai, col. 4, lines 50-51). By contrast to Dai, amended claim 1 provides that single wall carbon nanotubes are formed. Dai also does not disclose (nor does the Office Action assert that it does) that the catalyst layer has a thickness of between 1 micron and 30 microns. By contrast to Dai, amended claim 1 recites the use of a bimetallic or trimetallic metalorganic layer having a thickness between 1 micron and 30 microns. Thus, Dai fails to disclose multiple aspects of the present claims, including the use of a bimetallic or trimetallic metalorganic layer having the claimed thickness (i.e., between 1 micron and 30 microns), and the production of single walled carbon nanotubes.

The deficiencies of Dai are not remedied by Muroyama. Muroyama discloses a method of growing a carbon film using a thin layer of an organometallic catalyst. As conceded by the Office Action, Muroyama does not disclose that the catalyst may be bimetallic or trimetallic as recited in claim 1. (Office Action, p. 3). Muroyama also does not disclose a method for synthesizing single wall carbon nanotubes. By contrast to Muroyama, amended claim 1 provides

that single wall carbon nanotubes are formed. Muroyama also does not disclose (nor does the Office Action assert that it does) that the bimetallic or trimetallic metalorganic layer has a thickness of between 1 micron and 30 microns. In particular, each of the metal layers disclosed by Muroyama are in the sub-micron range (see e.g., Muroyama, page 11, paragraph [0145]; pages 13-14, paragraph [0170]; page 16, paragraph [0209]; and page 26, paragraph [0332]). By contrast to Muroyama, amended claim 1 recites a bimetallic or trimetallic metalorganic layer having a thickness between 1 micron and 30 microns. Thus, the combination of Dai and Muroyama fails to disclose multiple aspects of the present claims, including the use of a bimetallic or trimetallic metalorganic layer having a thickness between 1 micron and 30 microns, wherein single wall carbon nanotubes are formed.

The deficiencies of the combination of Dai and Muroyama are not remedied by Smalley. Smalley discloses a method of making single wall carbon nanostructures from metal particles. Like Dai and Muroyama, Smalley does not disclose a bimetallic or trimetallic metalorganic layer having a thickness between 1 micron and 30 microns. For instance, Smalley discloses transition metal clusters having "a size from about 0.5 nm to over 30 nm" and indicates that larger clusters are preferably inactivated by its process. (Smalley, column 6, lines 51-56). Smalley also provides that "[c]lusters in the range of 0.5 to 3 nm will produce single-wall nanotubes, while larger clusters tend to produce multiwall nanotubes…" (Smalley, col. 6, lines 52-54). By contrast to Smalley, amended claim 1 recites the use of a bimetallic or trimetallic metalorganic layer having a thickness between 1 micron and 30 microns. According to Smalley, single wall nanotubes would not be formed at the claimed catalyst thickness. Thus, the combination of Dai, Muroyama, and Smalley fails to disclose the use of a bimetallic or trimetallic metalorganic layer having a thickness between 1 micron and 30 microns, wherein single wall carbon nanotubes are formed as presently claimed.

The deficiencies of the combination of Dai, Muroyama, and Smalley are not remedied by Xu. Xu discloses a carbon fiber-based field emission device. Like Dai, Muroyama, and Smalley, Xu does not disclose a bimetallic or trimetallic metalorganic layer having a thickness between 1 micron and 30 microns that is capable of forming single walled carbon nanotubes. While Xu discloses catalyst film thicknesses "less than about 100 microns… [and] less than 10 microns…" (Xu, col. 7, lines 64-66), there is no indication in Smalley that catalyst films having

these thicknesses could yield single wall carbon nanotubes. According to Xu, the fibers produced "include single wall or multi-walled tubular structures," (Xu, col. 9, lines 31-33), however, none of the examples provided by Xu disclose a method for producing single wall carbon nanotubes nor any guidance regarding which catalyst thicknesses would yield single walled carbon nanotubes. Instead, Xu's Example 1 describes the use of an "iron, cobalt or nickel [film thickness of] 25 to 100 Å," which produces "carbon fiber emitters having diameters of 20-100 nm." (Xu, col. 19, lines 49-54). It is well known that nanotubes in this size range are not single walled. See e.g., http://en.wikipedia.org/wiki/Carbon_nanotube#Single-walled and Applicant's specification paragraph [0057]. At no point does Xu provide any description of conditions, including catalyst film thickness, which would yield single wall carbon nanotubes much less a disclosure of the use of a bimetallic or trimetallic metalorganic layer having a thickness between 1 micron and 30 microns, wherein single wall carbon nanotubes are formed. A mere disclosure of a catalyst film size range without further guidance cannot be said to provide a disclosure of the presently claimed catalyst thickness. By contrast to Xu, amended claim 1 recites the use of a bimetallic or trimetallic metalorganic layer having a thickness between 1 micron and 30 microns, wherein single wall carbon nanotubes are formed. Thus, the combination of Dai, Muroyama, Smalley, and Xu fails to disclose the use of a bimetallic or trimetallic metalorganic layer having a thickness between 1 micron and 30 microns, wherein single wall carbon nanotubes are formed as presently claimed.

**The Cited References Teach Away From the Presently-Amended Claims**

The Office Action alleges that "[o]ne of ordinary skill in the art would recognize that an electron emission device would have layers with thicknesses in the micron range." (Office Action, p. 6). Applicant respectfully directs the examiner to pages 22-23, paragraphs [0056] and [0057] of the specification as filed. In these paragraphs, the applicant demonstrates that the claimed thickness has a significant effect on the properties of the carbon nanostructures formed. Optimization of this thickness involves non-routine experimentation given the complexity of the system, and thus, it was not obvious to try the presently-claimed metalorganic layer thicknesses. The Office Action asserts that "Smalley do[es] not teach away from the [presently claimed catalyst] thickness…" (Office Action, p. 8). Applicant respectfully disagrees. According to Smalley, "[c]atalyst clusters in the range of 0.5 to 3 nm will produce single-wall nanotubes,

while larger clusters tend to produce multiwall nanotubes with outer diameters greater than 3 nm." (Smalley, column 6, lines 52-55). Thus, Smalley clearly teaches that the presently-claimed catalyst thicknesses (i.e., 1 to 30 microns) would "tend to produce multiwall nanotubes," and thus clearly teaches away from the claimed invention. *Id.* Xu's teaching of catalyst layers less than 100 microns cannot negate the fact that Smalley teaches away from the presently-claimed catalyst thickness for the production of single wall carbon nanotubes. Moreover, at no point does Xu provide any description of conditions, including catalyst film thickness, which would yield single wall carbon nanotubes much less a disclosure of the use of a bimetallic or trimetallic metalorganic layer having a thickness between 1 micron and 30 microns, wherein single wall carbon nanotubes are formed. Despite the teachings of the cited references, applicant demonstrates formation of single wall nanostructures (i.e., one-dimensional carbon nanostructures) using a metalorganic layer thickness of between 1 micron and 30 microns (see e.g., Example 2 of applicant's specification). Because Smalley teaches away from the presently claimed invention, it would not have been obvious to modify the combination of Dai, Muroyama, and Smalley using Xu as suggested by the Office Action to reach the presently claimed invention.

According to MPEP 2141.02(VI), "[a] prior art reference must be considered in its entirety, i.e., as a whole, including portions that would lead away from the claimed invention." Thus, the aspects of Smalley that teach away from the presently-claimed metalorganic layer thickness must be given proper weight along with the teachings of Xu. Selection of Xu's teaching of catalyst thickness over Smalley's teaching away constitutes improper hindsight based on applicant's specification.

**Summary**

Because the combination of Dai, Muroyama, Smalley, and Xu does not teach the use of a bimetallic or trimetallic metalorganic layer having a thickness between 1 micron and 30 microns, wherein single wall carbon nanotubes are formed, the combination does not teach each and every element of the presently claimed invention. Moreover, Smalley teaches away from the presently claimed catalyst thicknesses (i.e., a thickness between 1 and 30 microns) because it teaches thicknesses greater than 3 nm would "tend to produce multiwall nanotubes." (Smalley, column 6, lines 52-55). Therefore, the examiner is respectfully requested to withdraw the rejection of

claims 1, 3-15, and 17-19 under 35 U.S.C. § 103(a). For the reasons provided above, new claims 43-45 are also patentable over the combination of Dai, Muroyama, Smalley, and Xu because they depend from claim 1 and recite a bimetallic or trimetallic metalorganic layer having thicknesses of "less than 5 microns," "1 micron," and "2 microns," respectively, which are also not taught or suggested by the combination of Dai, Muroyama, Smalley, and Xu.

Claim 2

Claim 2 was rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Pat. No. 6,232,706 to Dai et al. ("Dai") in view of U.S. Pat. App. Pub. No. 2002/0036452 to Muroyama et al. ("Muroyama"), U.S. Pat. No. 6,692,717 to Smalley et al. ("Smalley"), and U.S. Pat. No. 5,872,422 to Xu et al. ("Xu") as applied above and further in view of U.S. Pat. No. 5,863,601 to Kikuchi et al. ("Kikuchi").

Because claim 2 depends from claim 1, it contains all the elements of claim 1. As discussed above, the combination of Dai, Muroyama, Smalley, and Xu does not teach all of the elements of claim 1. Kikuchi does not overcome the deficiencies of the combination of Dai, Muroyama, Smalley, and Xu because it also fails to disclose the use of a bimetallic or trimetallic metalorganic layer having a thickness between 1 micron and 30 microns, wherein single wall carbon nanotubes are formed. Accordingly, the combination of Dai, Muroyama, Smalley, Xu, and Kikuchi fails to teach all of the elements of claim 2 and cannot render it obvious. Therefore, the examiner is respectfully requested to withdraw the rejection of claim 2 under 35 U.S.C. § 103(a).

Claim 16

Claim 16 was rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Pat. No. 6,232,706 to Dai et al. ("Dai") in view of U.S. Pat. App. Pub. No. 2002/0036452 to Muroyama et al. ("Muroyama"), U.S. Pat. No. 6,692,717 to Smalley et al. ("Smalley"), and U.S. Pat. No. 5,872,422 to Xu et al. ("Xu") as applied above and further in view of U.S. Pat. No. 4,650,895 to Kadodura et al. ("Kadokura").

Because claim 16 depends from claim 1, it contains all the elements of claim 1. As discussed above, the combination of Dai, Muroyama, Smalley, and Xu does not teach all of the

elements of claim 1. Kadokura does not overcome the deficiencies of the combination of Dai, Muroyama, Smalley, and Xu because it also fails to disclose the use of a bimetallic or trimetallic metalorganic layer having a thickness between 1 micron and 30 microns, wherein single wall carbon nanotubes are formed. Accordingly, the combination of Dai, Muroyama, Smalley, Xu, and Kadokura fails to teach all of the elements of claim 16 and cannot render it obvious. Therefore, the examiner is respectfully requested to withdraw the rejection of claim 16 under 35 U.S.C. § 103(a).

## CONCLUSION

None of the cited references, individually or combined, teaches the use of a bimetallic or trimetallic metalorganic layer having a thickness between 1 micron and 30 microns, wherein single wall carbon nanotubes are formed. Moreover, Smalley teaches away from the presently claimed catalyst thicknesses (i.e., a thickness between 1 and 30 microns) because it teaches thicknesses greater than 3 nm would "tend to produce multiwall nanotubes." (Smalley, column 6, lines 52-55).

Applicants respectfully request prompt examination on the merits. If the examiner believes that a personal communication will expedite prosecution of this application, the examiner is invited to telephone the undersigned at the number provided below.

Applicants petition for a three (3) month extension of time in the amount of $1110. The Commissioner is hereby authorized to charge Deposit Account 19-2555 for the extension of time fees as well as any additional fees that may be required to render the present submission timely.

Respectfully submitted,

Dated: March 30, 2011 By: /Melissa Harwood/

Melissa M. Harwood, Ph.D., Reg. No. 60,229
Fenwick & West LLP
Silicon Valley Center
801 California Street
Mountain View, CA 94041
Tel. (206) 389-4550
Fax (650) 938-5200